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NOTES ON LIGNITE

ITS CHARACTERISTICS AND UTILIZATION

BY

S. M. DARLING

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NOTES ON LIGNITE, ITS CHARACTERISTICS AND UTILIZATION.

By S. M. Darling.

INTRODUCTION.

This short summary of present information on the composition and utilization of lignite is issued by the Bureau of Mines for the purpose of outlining problems that are of immediate and urgent importance to the upholding and maintenance of the utmost efficiency in the industrial activities of the Nation.

CLASSIFICATION OF COALS.

When ranked according to value, the coals in the United States fall into three groups: (1) Anthracite, semianthracite, semibituminous, and bituminous coals; (2) subbituminous coals; (3) lignite.

This classification rests partly on the percentages of volatile matter, oxygen, and moisture in the coals. There is, speaking generally, a progressive loss of these elements in passing from lignite to anthracite. But chemical criteria alone do not give a sufficient basis for classification. The dividing lines are really determined by physical characteristics that directly affect the market value of the coals.

Although subbituminous coals generally have more moisture than bituminous coals, there are so many exceptions to this rule that it has little value as a means of distinction. However, there is a marked difference *in behavior on weathering:* The subbituminous coals, on exposure, give up their moisture more readily; as a result they shrink, crack irregularly, and in a measure disintegrate; whereas the bituminous coals on drying shrink very little and show practically no disintegration.

Again, between subbituminous coal and lignite there is no clearly defined chemical difference; but the physical difference is marked. The subbituminous coal is black and shiny, has little trace of woody structure, carries less moisture, has a greater heating value than lignite, and is capable of yielding fairly good coke. Lignite, on the other hand, is brown, dull, markedly woody in texture, has no cok-

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ing quality whatever, carries a greater percentage of moisture, which it gives up readily; its disintegration on exposure is so rapid as largely to prevent its shipment any distance except during the excessively cold northern winters when it is, of course, frozen.

The Nation's coal resources of all ranks total 3,553,637,100,000 minable tons of 2,000 pounds, 1,051,290,000,000 tons, or nearly one-third, being lignite. Of this lignite 964,424,000,000 tons is in North and South Dakota and northeastern Montana, approximately 23,000,000,000 tons in Texas, 7,404,300,000 tons in Alaska, and relatively smaller quantities in several of the other Western and Southern States.[a]

The lignite tonnage given above includes only group 3 (true lignite); it does not include group 2 (subbituminous coal), which in earlier days was called "black lignite" and classed with group 3.

CHARACTERISTICS OF LIGNITE.

It is an important economic consideration that these lignites are found in those parts of the country that have no other solid fuel. They compare substantially as follows:

Average proximate analyses of lignite.

	Arkansas.	Texas.	North Dakota.
Moisture, per cent	29.73	28.63	27.13
Volatile hydrocarbons, do	37.87	32.53	29.11
Fixed carbon, do	23.95	30.43	36.16
Ash, do	8.45	8.41	7.60

The Alaska lignite closely resembles that of Texas and North Dakota.

The sulphur content of the lignite in these fields rarely exceeds 1 per cent. The average heating value is about 7,500 British thermal units per pound.

The feature that distinguishes Arkansas lignite from the others is a high percentage of volatile matter, which yields large quantities of oils and tars.

The large content of moisture in lignite has not been absorbed from extraneous sources, but is that portion, in part chemically combined, which remains from the water present in the peat from which the lignite was derived. This water is poor stuff on which to pay freight or put into a furnace; further, its partial evaporation in warm weather causes rapid disintegration or "slacking," thereby reducing the practical shipping radius during such weather almost to zero. Lignite takes fire quickly from spontaneous combustion, so that its safe storage in even small quantities is exceedingly difficult. It does not "coke," in

[a] Campbell, M. R., The coal fields of the United States: U. S. Geological Survey, Professional Paper 100, 1917.

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the sense that bituminous coal cokes, but rather crumbles when being carbonized or when thrown into the fire, and this gives rise to difficulties in firing and substantial loss, as unburned fuel, through the grate bars.

FUEL NEEDS OF LIGNITE AREAS.

For these reasons, lignite is not a desirable fuel as mined, and millions of tons of bituminous and anthracite coals are shipped annually into the lignite-bearing regions—literally an example of "carrying coals to Newcastle." The results are high prices for both industrial and domestic fuel, the imposition of a great handicap on the industrial development of these regions, the tying up of much transportation equipment needed for other service, and other economic lost motion.

Thus the economic problem involved in the utilization of lignite is not a local but a national one.

In Texas there is some bituminous coal, but not enough even to supply the railroads.

In Alaska $50,000,000 is being spent on a railroad, and it seems probable that the development of a large part of the territory served by this railroad will depend upon utilization of lignite.

In North Dakota, in 1917, 603,000 tons of lignite was mined, and 717,000 tons of bituminous coal was imported from Lake docks, Indiana, and Illinois.

In South Dakota, in 1917, there was mined 12,000 tons of lignite, and 972,000 tons of bituminous coal was imported from the Lake docks, Kentucky, West Virginia, Iowa, Indiana, and Illinois.

Minnesota, a State containing no coal, in 1917 imported 7,203,000 tons of bituminous coal from the Lake docks, Kentucky, West Virginia, Ohio, Tennessee, Iowa, Arkansas, Indiana, and Illinois.

The territory naturally tributary to the Dakota lignite deposits embraces North Dakota, South Dakota, and western Minnesota. Upwards of 2,000,000 tons of bituminous coal is shipped annually into that territory from Illinois, Indiana, West Virginia, Kentucky, and Pennsylvania. The average haul of this coal is 1,000 miles. If the Dakota lignite were put into stable and serviceable condition, by means of carbonizing and briquetting, this fuel demand could be supplied with an average haul of less than 400 miles. The average freight rate is about 4 mills per ton-mile. Therefore, if the fuel and power requirements of the area tributary to the Dakota lignite fields were supplied from the lignite mines an annual saving would be effected of $4,800,000 in freight charges alone. Such utilization of near-by fuel would also save annually the travel of 50,000 cars and 1,200 engines and crews a distance of 600 miles.

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The economic waste involved in such almost transcontinental shipment of coal is little short of criminal.

The tonnage mentioned does not include the anthracite shipped into this Dakota territory; this anthracite, carried in Lake boats and distributed from the head of Lake Superior, amounts to about 1,500,000 tons annually.

The United States Fuel Administration made heroic efforts to correct this condition, so far as it lay within its power, by forbidding some of these long hauls, but the fact remains that the people in that rigorous climate must have fuel, and the evil can not be entirely eliminated until lignite is made more generally available.

All of the coal imported into North and South Dakota and a substantial part of that consumed by Minnesota should be replaced by lignite from the Dakota fields. It can be if the lignite is properly prepared, by means of drying, carbonizing, briquetting, or such combinations of these processes as the market demands.

WASTE IN PRESENT METHOD OF BURNING COAL.

To burn high volatile coals on furnace grates is wasteful. Our leading engineers and chemists have for many years decried the waste of burning bituminous coal raw; they have time and again shown that it is far more economical to break the coal up, by means of carbonization, into its constituents—solid carbon, gas, ammonia, oils, and tars—thus releasing these valuable products for use in their appropriate fields.

The fixed carbon is easy to burn because it stays on the grate. The tars and the more complex gases distilled from the coal and rising from the fuel bed are quickly decomposed into soot and simple gases; the soot in large measure passes out of the stack as black smoke, adding the element of nuisance to that of waste. Heat in the form of coal gas brings 8 to 16 times the price of an equivalent amount of heat in the form of coal. Benzol, toluol, and other oils are obtained as a result of the carbonization of coal, and the value of heat in this form of motor fuel is 20 to 30 times as great as that of heat in the form of coal.[a] Further, the cheapest method of obtaining nitrogen products for use in explosives or fertilizers is to procure them from the ammonical liquor and gas that are obtainable by carbonizing coal, or its gasification in by-product gas producers.

It is undeniable that in the future the principal use of high volatile coals will be in by-product gas plants because of the higher commercial value of the products of carbonization. It is even suggested that "the time may come when our views of the relative values of

[a] Kreisinger, H., Augustine, C. E., and Ovitz, F.K ., Combustion of coal and design of furnaces: Bull. 135, Bureau of Mines, 1917, p. 136.

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the different coals will change and we shall consider anthracite as of minor importance as compared with the high-volatile bituminous coals."[a]

In Bulletin 102, part 4, of the National Museum, there appears the following suggestion:[b]

> It is not beyond the bounds of reason to foresee a condition whereby a householder, in the place of his ton of anthracite which he now welcomes for $11, will receive a ton of smokeless coal without slate, a month's supply of cooking gas, 40 miles of motor fuel, enough fertilizer to start a small garden, and tar sufficient to allay the dust in front of his house—all for far less money than he now pays for inferior coal.

This picture is not a fanciful one; our high-volatile coals and lignites contain precisely these possibilities within themselves. The German Government has long had its chemists at work devising new plans for the better utilization of its coal, and finally has imposed a flat surtax of 20 per cent ad valorem upon all coal which is not distilled or treated for its by-products.

Because of the inherent shortcomings, as fuel, in the raw lignite itself, one can safely say that it will never be much used in its natural state. The one fact of containing 30 per cent water would of itself prevent use elsewhere than in the immediate vicinity of the mine. Therefore, the treatment, or carbonization, of the lignite, which is absolutely essential to more general use, is strictly in accord with modern scientific research. We are simply, from necessity, starting now to do with lignite what will be done eventually with all of our high-volatile coals.

EFFICIENT UTILIZATION OF LIGNITE.

Some progress has been made in the way of a better utilization of lignite. Instructive experiments have been made by the United States Bureau of Mines, the State of North Dakota,[c] and the Province of Saskatchewan, Canada,[d] which bring the matter measurably nearer to a satisfactory solution.

Instead of trying to burn the raw lignite in the primitive and wasteful ways now employed, the lignite should be treated so as to yield several products, each peculiarly adapted to a particular commercial need, as follows:

1. *Dried lignite*, for use on automatic stokers and in fuel-gas producers. Because of its more or less soft and comminuted condition

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[a] Kreisinger, H., Augustine, C. E., and Ovitz, F. K., work cited, p. 137.

[b] Gilbert, C. G., and Pogue, J. E., Coal: The resource and its full utilization: U. S. Nat. Museum Bull. 102, pt. 4, 1918, p. 15.

[c] Babcock, E. J., The economic utilization of western lignite: Bull. 89, Bureau of Mines, 1915, 73 pp.

[d] Darling, S. M., The carbonizing and briqueting of lignite, Government of Saskatchewan, Canada, 1915, 47 pp.

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the dried lignite can not be handled advantageously by hand, but it can be used satisfactorily by mechanical means.

2. *Powdered fuel*, from the dried, pulverized lignite, for use in cement kilns, under locomotive boilers, and in other large furnaces. Because of its high volatile content this pulverized lignite makes an exceptionally good powdered fuel. The pulverized lignite can also be used in fuel-oil burners in conjunction with fuel oil. An oil mixture containing 30 per cent dried and finely pulverized lignite will still act as a fluid and can be burned as a liquid fuel. This would not only greatly conserve petroleum resources, but would effect a great saving in the cost of raising steam.

3. *Dried lignite briquets*, for large hand-fired industrial furnaces and heating plants. Where it is necessary to handle the dried lignite with a fireman's shovel it should be briquetted. Tests of these dried lignite briquets in commercial boiler furnaces have proved them to be equal to good Middle West bituminous coal.

4. *Carbonized lignite*, for use in suction power-gas producers. Tests of carbonized lignite, in carload lots, have shown it to be an unexcelled fuel for such producers. Its chemical composition, as shown by analysis, is about the same as that of Pennsylvania anthracite. In carbonizing the lignite the objectionable tar found in all coals containing a substantial quantity of volatile matter is removed, and the gas goes to the cylinder of the gas engine clean and tar free. For the production of power in this way the carbonized lignite is fully equal, pound for pound, to anthracite, charcoal, or bituminous coke, the standard fuels for this purpose. Carbonized lignite can also be burned satisfactorily on the automatic stokers and grates used for the smaller sizes of anthracite.

5. *Carbonized lignite briquets*, for domestic service in house-heating stoves and furnaces, fireplaces, and cooking ranges. This fuel, ton for ton, compares favorably with anthracite, and is an ideal domestic fuel in such rigorous climates as those of North Dakota and Alaska. In climates where the thermometer not infrequently goes to 40 below zero the demand for such fuel is immediate and very large.

6. *Sulphate of ammonia and producer gas.*—The raw lignite, just as mined, when consumed in by-product gas producers of the Mond type, yields sulphate of ammonia, producer gas, and some tars of undetermined value; there is no solid residue except ash. On the average, lignite carries about 1.40 per cent nitrogen. If this nitrogen were wholly recovered as sulphate of ammonia the yield would be about 147 pounds per ton of lignite. This theoretical yield, of course, could not be obtained in commercial practice; the actual yield of sulphate of ammonia per ton of lignite gasified would be 70 to 80 pounds. Ammonium sulphate is now selling for 6 to 7

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cents per pound; before the war it sold for 3 to 3½ cents per pound. As the price of this commodity is determined in world markets, it will probably drop back to near the prewar price when industrial conditions again become normal. The gas yield per ton of lignite would be 60,000 to 70,000 cubic feet, of about 140 B. t. u. per cubic foot. This gas could be used as a furnace fuel or in a gas engine to produce power. If used in the latter manner it would yield 700 to 800 horsepower-hours per ton of lignite gasified.

LIGNITE EASY OF MANIPULATION.

The fact that the lignite does not coke in the sense that bituminous coal cokes, but rather crumbles, on being carbonized, makes possible a continuous and comparatively inexpensive distilling process, thus obviating the laborious and expensive charging and drawing of retorts as practiced in coal-gas plants. Moreover, lignite parts with its volatile content more readily than does bituminous coal. The entire process of carbonization is mechanical; the fuel need not be handled by manual labor from the time the lignite is loaded into the mine car until the briquets are en route to the consumer. The costly element of labor is reduced practically to that required for directing mechanical operations.

BY-PRODUCTS FROM LIGNITE.

In carbonizing the lignite valuable by-products are obtained in the form of gas, ammonia, oils, and tar.

GAS.

The gas yield is upward of 10,000 cubic feet per ton of lignite, and the gas has a heating value of 400 to 450 B. t. u. per cubic foot.

A little more than one-half of the gas is necessary to carry on the carbonizing process; the balance can be used as a city gas for cooking, or for lighting if burned in a mantle, or for furnace fuel, or for generating power by means of a gas engine. Or, if desired, the entire 10,000 cubic feet can be devoted to these purposes and the carbonizing carried on with lignite producer gas from a fuel-gas producer.

If the gas were used as a "town gas" and a higher thermal value than 400 B. t. u. per cubic foot were required, the whole 10,000 cubic feet could be enriched to the desired standard. In a carbonizing oven of the Saskatchewan type this enriching can be done continuously as the carbonizing proceeds, without the expenditure of additional fuel, by passing the enriching oils through the carbon residue at the point of its highest temperature. Petroleum oils or the oils distilled from the lignite itself may be used for this purpose. Or,

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the poorer portion of the gas could be collected separately and only the richer portion, 6,000 to 7,000 cubic feet, sent into the city mains. The inferior gas would not be wasted, but, supplemented if necessary by producer gas, could be used as the oven fuel. If it were desirable to do the carbonizing exclusively with the oven gas, the amount of richer gas available for distribution in city mains would be reduced to 3,000 or 4,000 cubic feet per ton of lignite.

The future for gas seems to lie in its use as a fuel rather than as an illuminant, hence the prime consideration is one of heat units rather than of candlepower. The advent of the Welsbach incandescent mantle, which depends upon heat units for its efficiency, rendered obsolete the open-flame or "bat-wing" burner, which necessitated a gas of high candlepower. The mantle does not require candlepower in the gas and gives a splendid light even with coal gas of low heating value. Because of these economies, the use of mantles has become practically universal. Despite this condition, many municipal gas franchises still prescribe antiquated candlepower requirements, through sheer ignorance of the facts. The public is the loser by such a policy, because the gas companies are compelled to make their gas by processes which are needlessly expensive and which make it impossible to give the public the benefit of the lower price of cheaper processes where gas is sold by heat-unit specifications instead of by candlepower.

Oil is the factor of greatest expense in the manufacture of carbureted water gas, which is the kind of gas commonly supplied to cities. A change to a heat-unit basis would permit the manufacture of gas from coal without the use of oil and thus would enable the gas company to reduce the price of gas to the consumer. As illustrating the cost of this enriching by oil to secure a high candlepower, Chicago uses annually 80,000,000 gallons of gas oil, or more than the United States Navy's oil consumption in 1916.

The point is succinctly stated by Arthur Hewitt, general manager of the Consumers' Gas Co. of Toronto, in an address made before the Canadian Gas Association last August, published in the September, 1918, issue of the American Gas Engineering Journal.

> When we asked the Government to set a standard of 500 B. t. u. for town gas, we were very modest, but in their wisdom they decided on a standard of 520 B. t. u. Experience has shown that there is economic waste in this standard, and now that there is a national necessity for conserving coal and gas oil it is a matter of regret that the Government has not yet seen its way to so revise the gas act as to permit gas companies to manufacture and supply gas of a quality suited to present needs, having regard to the importance of restricting the quantity of raw materials required in its manufacture, to the utmost practical limit. From the standpoint of the consumer it would mean little or nothing if the standard for gas was fixed at, say, 460 to 470 B. t. u., while the saving of even a moderate amount of coal or gas oil would be a matter of national importance.

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The director of the oil division of the Fuel Administration has proposed that the heating values of carbureted water gas sold for domestic use shall be not over 528 B. t. u. per cubic foot. In 1911 in England a standard of 500 B. t. u. per cubic foot was fixed upon. During the war, where the gas was stripped for benzol, this requirement was permitted to drop to 450. The Public Service Commission of Massachusetts in 1917 adopted 528 B. t. u. per cubic foot as standard. During the war the coal shortage in Italy became so acute that the gas fell to 225 B. t. u. from a previous 560. The experience there leads the president of the Italian Gas Association to the view that a gas of 340 B. t. u. would adapt itself satisfactorily to private uses and industrial heating. There are many high authorities in the gas world who insist that for heating, cooking, and for lighting in burners equipped with mantles, the candlepower requirement is wholly useless, and that the gas which gives the best over-all economy to both producer and consumer is one which contains 400 to 450 B. t. u. per cubic foot. One authority says 350. The prime object is to extract the maximum B. t. u. per ton from coal alone and to sell this heat at a reduced price and sell more of it.

The low sulphur content of lignite is a good feature, because almost no corrosive acid is formed from the combination of sulphur with water when the lignite is burned. Should the lignite gas be used as a "town gas" for heating, cooking, and illuminating purposes, there would be almost no sulphureted hydrogen to be removed by means of hydrated oxide of iron in purifiers.

As to power obtainable, of the yield of 10,000 cubic feet per ton of lignite carbonized, 6,000 cubic feet are required to carry on the process, leaving a surplus, costing nothing, of 4,000 cubic feet, of 400 B. t. u. per cubic foot, or a total of 1,600,000 B. t. u. A good gas engine uses about 10,000 B. t. u. per horsepower-hour, hence the surplus gas from each ton of lignite carbonized would yield 160 horsepower-hours. This power is comparable in cost with that derived from natural gas, and is fully as cheap as most hydroelectric power.

Of course, this cheap power is limited to the quantity of lignite carbonized. But the first need of the people in northern climates is domestic fuel, hence the demand for the carbonized lignite briquets would be large. As the population and the demand for power increased, the demand for this carbonized fuel would grow apace. If the demand for power in any lignite field should outrun this supply of surplus gas, the amount of power can be readily and cheaply augmented by using carbonized lignite in power gas producers.

It is not necessary to dwell on the benefits that would ensue to the lignite regions from thus placing them in possession of a fuel equal to anthracite and a supply of cheap electrical power.

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AMMONIA.

The ammonia is contained in the gas and gas water; it may be recovered as ammonium sulphate—a valuable fertilizer—as anhydrous ammonia, for refrigeration and other commercial purposes, or it may be treated as a source of other nitrogen products, some of which are of vital importance in the manufacture of explosives. As already stated, this and the Mond by-product gas-producer process are the cheapest sources of these nitrogen products, but the amount that can be so recovered is limited to the tonnage of coal carbonized or gasified. The manufacturing practices involved have long been standardized.

OILS AND TARS.

Just what is the most profitable disposition in this country for the oil and tar products remains to be determined. Their treatment and marketing is an industry by itself.

The simple distillation products of the oil can be put to many uses, such as fuel oil for furnaces and internal-combustion engines, creosoting oils for the preservation of timber, waterproofing and preserving oils for leather and cotton and other fabrics, also in tar paper, roofing pitch, etc. Without doubt the anthracene and creosote oils will find a ready market as wood and leather preservatives.

The pitch makes an excellent binder for the briquets and will go far toward reducing the cost of briquetting if more valuable uses are not found for it.

From the several fractions, by exhaustive distillation and treatment, are derived hundreds of synthetic products in the way of paraffin, acids, antiseptics, photographic chemicals, aniline dyes, perfumes, drugs, preservatives, etc.

From the light oils come benzol, toluol, aniline dyes, photochemicals, certain drugs, and many other chemical products. From the carbolic and creosote fractions are derived carbolic acid, creosote, picric acid, photodyes and chemicals, coloring materials, and numbers of perfumes. The anthracene oils give, among other things, alizarin, a valuable acid used in the production of dyes, and carbolineum, used as a wood preservative. This latter product is analogous and equal in value to the carbolineum derived from European lignite, which before the war was imported in large quantities and retailed at 65 cents a gallon in barrel lots.

At first, of course, the simple distillation products will be procured and marketed as such; but, as opportunity affords, each of these primary by-products will be investigated and synthetic chemical products will be manufactured. The exact course of this development will have to be determined in conjunction with a careful study of the market.

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Almost all of these manufactured products of tar have heretofore come from Germany. In 1913 the United States imported coal-tar products that were valued at $11,000,000 at initiating points and probably cost double that amount when they reached the consumer. Many millions of gallons of creosoting oils for preserving timbers have been imported annually. As imports are now cut off the market value of these commodities on this continent is greatly enhanced. It is not unreasonable to expect that in the future a large part of the demand for tar products will be supplied from our immense stores of lignite.

Light hydrocarbon oils of the class including benzol make a serviceable motor fuel, and their effectiveness is somewhat increased when mixed with gasoline; the light oils from lignite can very economically be used in this way and thus in a measure eke out the failing supply of gasoline. The indications are that the consumption of motor fuel within the next decade will be double the present gasoline production. The heavier oils might be used as fuel in the steam type of automobiles. In many quarters alcohol is looked upon as one of the ultimate sources, if not the main source, of motor fuel. Used alone, its efficiency is reduced because of its high oxygen content. Commercial alcohol and gasoline are not readily miscible; alcohol and benzol are; and, after the benzol is added to the alcohol, the mixture will take up a high percentage of gasoline. It may well be that a large use for the benzol production will serve as the connecting link between gasoline and alcohol, aiding in the introduction of alcohol as a staple market commodity.

Certain Arkansas and Texas lignites are known to be substantially undeveloped cannel coals containing a large percentage of volatile matter. It is probable that the day will come when these lignites will be distilled for products similar to the oils now being recovered from the oil shales of Scotland and elsewhere.

POSSIBLE CONSERVATION OF PETROLEUM AND NATURAL GAS.

Bringing Texas lignite onto the market as fuel would release large quantities of Texas petroleum and natural gas for other uses, and the conservation of our petroleum resources is a more important matter than the average man appreciates.

Of our original supply of petroleum, 42 barrels per capita have been used and only 70 barrels per capita remain for the future. About half of the petroleum currently produced is used as fuel for steam raising. The possibilities in the use of petroleum and its products in connection with the Navy, airplanes, the merchant marine, automobiles, motor trucks, and tractors are so great and vital that before long the use of oil for steam raising will be regarded as an

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inconceivable folly, the most glaring economic perversion that this country has ever committed.[a]

Mr. Requa,[b] Consulting Engineer of the Bureau of Mines and Director of the Petroleum Division of the Fuel Administration, puts the situation in forcible language:

> Those of us who believe that posterity must settle these problems of heat, light, and power are living in a fool's paradise, and must inevitably awaken within the next few years to face, subdued and chastened, the real truth.
>
> The operation of hydroelectric generators, of railways, and trolley cars, of the machinery of the factories, of internal-combustion engines, of our battleships and our merchant ships, in fact, of all machinery, is made possible by the use of one product, and of one product alone—petroleum.
>
> For it there is no known satisfactory substitute as a lubricant; its exhaustion spells commercial chaos or commercial subjugation by the nation or nations that control the future source of supply from which petroleum will be derived. There is but one escape, and that is the discovery of some substitute, now unknown, that will as efficaciously and economically lubricate the machinery of the Nation, from the handicraft of the watchmaker to the dreadnaught of the Navy. * * *
>
> We must either plan for the future or we must pass into a condition of commercial vassalage, in time of peace relying on some foreign country for the petroleum wherewith to lubricate the highways of commerce, in time of war at the mercy of the enemy who may either control the source of supply or the means of transportation; in either event our railways and factories will cease operation, our battleships will swing helplessly at anchor, and our country will resound with the martial tread of a triumphant foe.

Efforts are being made in France to introduce the distillation of lignite for tars. The Societé de Distillation des Combustibles, Paris, is constructing an improved Ziegler type of furnace similar to that used for the distillation of peat, a type yielding about 7 per cent of tar.

In one place in Germany where the system was adopted 70 to 80 per cent of marketable products was obtained from lignite tar, namely, 15 to 20 per cent paraffin wax, 5 to 20 per cent kerosene, 5 to 15 per cent of creosotes and organic acids, the remainder being light products—petrol, etc.—or heavy products, such as gas oils and lubricating oils.

Concurrently with the great interest taken in the development of the shale-oil industry in America, it is worth while to consider the possibility of utilizing the large deposits of low-grade lignites for another set of greatly needed chemicals, including the fixed nitrogen, which can be converted into ammonium sulphate. Among the available products are benzol and toluol, and the gas can be employed in many places for industrial purposes.[c]

If we are to prevail against our enemies in time of war and maintain our commercial prestige during peace we must not be less diligent than either friends or foes in the matter of developing and conserving our natural resources.

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[a] Gilbert, C. G., and Pogue, J. E., Petroleum: A resource interpretation. Bulletin 102, pt. 6, U. S. National Museum, 1918, pp. 25–39.

[b] Requa, M. L., "Petroleum Resources of the United States," Senate Document No. 363, 64th Cong., 1st sess., 1916, pp. 5, 18.

[c] Distillation of lignite: Mining and Scientific Press, vol. 116, May 11, 1918, p. 22.

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In respect to the world's future demand for fuel oils, the London Financier, the leading financial paper of London, says in a recent issue:

> Of all the commercial propositions of the world, probably none has greater potentialities than the oil industry. Although throughout the centuries a staple product of the earth, oil, until comparatively recent years, was never utilized to any extent as a motive power, owing to the poverty of invention in respect to engines adequate for its proper exploitation in that respect.
>
> The war, however, has brought about many wonderful changes, necessity having truly proved the mother of invention, and, among other things, oil engine invention has received a vast stimulus, with the result that perfection in the manufacture of the necessary machinery is now being rapidly approached and, at the same time, scope for the usefulness of liquid fuel enormously extended.
>
> It is indeed quite reasonable to prophesy that the next generation will witness the practical disappearance of coal as the motive power for railways and ships, so that "King Oil" may become a greater potentate on both land and sea than the veteran monarch of motion, "King Coal."

These lignite deposits lie in those parts of the country that are largely devoted to agriculture, where the demand for motive power in the form of tractors is large. It is logical to expect that the marketing of the lignite fuel oils will substantially reduce the present high cost of tractor fuels in those sections. Another item in this connection: There has been a considerable development of gas-producer tractors in Europe. The carbonized lignite, being practically dense charcoal, is especially easy of manipulation in the producer, and it is within the bounds of possibility that gas-producer tractors, consuming carbonized lignite, will prove an inestimable boon to the farmers and others in these agricultural sections. To till the ground by means of power derived from the coal mined beneath the surface carries an element of economic romance.

ADVANTAGES IN CARBONIZING LIGNITE.

A number of substantial economies, from the standpoint of the mine operator or coal dealer, become available through this method of carbonization of the lignite. The prime advantage is that the lignite is changed from an unstable commodity into several stable and valuable products, the demand for every one of which is large and increasing.

In the use of raw lignite under present practice thousands of tons of screenings are wasted annually. The coal is forked over in the mine room and screened again at the surface when loaded into the railroad cars. If the problem were handled as has been outlined above, this waste would be eliminated—every pound of lignite broken from the seam could be put to some profitable use.

Raw lignite can not be stored economically; the treated product can be. Hence, another large saving would result from the mines being able to work under stable conditions the year around, instead of only during the winter months, as at present.

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In discussing lignite, one of the highest English authorities, Dr. William Bone,[a] professor of chemical technology in the Imperial College of Science and Technology, London, and chairman of the British Fuel Economy Committee (1915–1917), in a book just off the press, makes the following statement:

> On low temperature distillation they yield a variety of valuable decomposition products, including petrols, kerosene, fuel and lubricating oils, solid paraffins, pitch, ammonium sulphate, the nature and uses of which have for some time past been the subject of close investigation in the author's laboratory. There are undoubted commercial possibilities in the world's lignite resources which will well repay the attention of fuel chemists.

In conserving the coal and petroleum resources and in increasing the electrical power supply of the country, lignite resources must be developed as well as water powers. With regard to the extent to which we may expect hydroelectric power to take the place of power from coal, the following statement by Steinmetz[b] is interesting and authoritative:

> Assuming an efficiency of 60 per cent from the stream to the distribution centers, there remain 230,000,000 kilowatts (24-hour service) as the maximum possible hydroelectric power which could be produced if during all seasons every river, stream, brook, or little creek throughout its entire length, from the spring to the ocean, together with all the waters of the freshets, could be and were used.
>
> This maximum possible hydraulic energy of 230,000,000 kilowatts is little more than the total energy which we now produce from coal, and is about equal to the present total energy consumption of the country, including all forms of energy.
>
> This is rather startling. It means that the hope that when coal once begins to fail we may use the water powers of the country as source of energy is and must remain a dream, for if to-day all the potential water power of the country were developed and every drop used it would not supply our present energy demand.
>
> Thus hydraulic power may and should supplement coal as a source of power but can never replace it.
>
> This probably is the strongest argument for efforts to increase the efficiency of our means of using coal.

There is a large demand for electrical power in central Texas close to the lignite beds. Seldom is there water present in sufficient quantities for condensing purposes for steam-turbine power plants. Hence the future supply of power for central Texas must come from lignite, whether used in the raw state in by-product producer gas plants, as carbonized lignite on automatic stokers under steam boilers or in power-gas producers, or as surplus gas from the carbonizing process used in a gas engine.

There are several uses for the lignite retort gas, as a town gas, as a furnace fuel, and in a gas engine. There are also several uses for

[a] Bone, W. A., Coal and its scientific uses, 1918, p. 68.

[b] Steinmetz, C. P., America's energy supply: General Electric Review, July, 1918, p. 457.

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the carbonized residue, in gas producers, on stokers, or in briquetted form. Therefore, it ought not to be difficult to market in one way or another either of these products, no matter how large the demand for the other might become. It is not easy reasonably to conceive a limit to the market for sulphate of ammonia or for hydrocarbon oils and tars.

The carbonizing of lignite will place the lignite-bearing regions substantially on a par as regards fuel and power with those parts of the country that are favored with bituminous coal. It will give a better domestic fuel in the way of carbonized lignite briquets, a better gas producer fuel in the form of carbonized lignite, enormous quantities of gas to be used for fuel or power purposes, a large tonnage of fertilizer in the form of sulphate of ammonia, and a great amount of oils and tars. Indeed, the products resulting from the carbonization of the lignite are so numerous and varied, and both products and uses can be varied in so many ways, that it is difficult to imagine a community which could not use all of such products or whose needs the products could not be so varied as to fit.

That the project of developing our lignite resources is not a small matter may be demonstrated by considering the area tributary to the North Dakota fields. Into this section there are now being imported a minimum annual tonnage of 2 million tons of bituminous coal and 1 million tons of anthracite, every pound of which should and some day will be replaced with fuel from these fields.

To replace these 3 million tons would require the carbonizing annually of 6 million tons of lignite, yielding 3 million tons of solid fuel, 18 billion cubic feet of surplus gas (costing nothing), 45 thousand tons of sulphate of ammonia, and 60 million gallons of tar distillates, comprising benzol, carbolic, creosoting, and anthracene oils, paraffin, and a substantial recovery of benzol upon stripping the gas.

The waste in dollars and cents involved in two years' shipping of outside coal into that territory would probably pay for all the equipment necessary to carry on the industry on the scale outlined.

The reader should bear in mind, too, that the Texas lignite situation affords even greater opportunity for economic saving. The opportunity in Alaska is also very large. And there are many smaller deposits of lignite scattered over the Southern and Western States, where relatively smaller savings can be made in similar fashion.

In several parts of Texas there are merchantable deposits of iron ore. Limestone is close at hand. The development of these deposits has been unprofitable because of the high price of coke, but under the present stimulus of high war prices for pig iron a blast furnace will soon be put into operation at Rusk, notwithstanding the fact that the Alabama coke which will be used will cost $16 a ton at Rusk. The carbonized lignite, or the carbonized lignite briquets, should replace this coke at not more than half the price. The lignite, iron,

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and limestone lie within a few miles of each other. The development of a steel industry in Texas would be an inestimable boon to the Southwest.

NEED OF GOVERNMENT AID FOR FURTHER INVESTIGATION.

Unquestionably the experiments so far conducted open wide economic and commercial possibilities, and it is believed that broader and more thorough investigation will point the way for the establishment of carbonizing and briquetting plants throughout the lignite-bearing regions of the country, thus bringing one of our largest natural resources effectively into the industrial world. The results will be not only the production of a first-class solid fuel, so much needed, but the saving of many by-products valuable in war as well as in peace and the easing of overburdened transportation conditions throughout the country.

One has only to observe how many of the necessities and comforts of daily life are dependent upon fuel to realize the vast import of its growing scarcity. A Government—in our nation the people collectively—can do many things for the general welfare which can not be done so well, if at all, by the individual. The conservation of this great natural resource, so necessary to the well-being of the citizen as well as to the nation as a whole, is surely a most logical subject for governmental organization and supervision.

The manufacturing industries of the United States must compete in world markets. The scale of living of the American workingman is perhaps the highest in the world. This is good. It would be economic folly to reduce this scale of living in order to remove this apparent disadvantage to our manufacturers. It is confidently urged that the best way to meet this seeming handicap is through wise and scientific conservation of our wonderful natural resources under Federal direction.

Although any encroachment by the Government upon what is popularly deemed the field of private industry may be regarded askance by the public; yet, if the Nation's natural resources are to be conserved and the fullest possible benefit obtained from them, some authority having a wider vision than any single industrial concern intent upon earning dividends must exercise a certain degree of surveillance and afford a measure of constructive help in coordinating the innumerable features of industrial interrelationships. A constructive economic policy of this character is a true Government function, and should insure rather than jeopardize legitimate gain from private enterprise.

Our pride should be not merely in our possession of this bountiful land, but in the extent to which we discover its resources and in the degree of the efficiency with which we devote them to the service of mankind.

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